On the failure of scientific research: an analysis of SBIR projects funded by the U.S. National Institutes of Health

By: Martin S. Andersen, Jeremy W. Bray, and Albert N. Link

Andersen, M.S., Bray, J.W. & Link, A.N. On the failure of scientific research: an analysis of SBIR projects funded by the U.S. National Institutes of Health. *Scientometrics* **112,** 431–442 (2017). https://doi.org/10.1007/s11192-017-2353-7

Abstract:

The Small Business Innovation Research (SBIR) program is the primary source of public funding in the United States for research by small firms on new technologies, and the National Institutes of Health (NIH) is a major contributor to that funding agenda. Although previous research has explored the determinants of research success for NIH SBIR projects, little is known about the determinants of project failure. This paper provides important, new evidence on the characteristics of NIH SBIR projects that fail. Specifically, we find that firms that have a founder with a business background are less likely to have their funded projects fail. We also find, after controlling for the endogenous nature of woman-owned firms, that such firms are also less likely to fail.

Keywords: technology | innovation | R&D | small firms | SBIR | NIH

Article:

Introduction

This paper focuses on research projects funded by the U.S. National Institutes of Health (NIH) through their Small Business Innovation Research (SBIR) program.[1] As we discuss below, these science-based R&D projects are expected to result in new technologies that will eventually be commercialized.[2] However, not all of these projects are successful; that is, some of the projects are discontinued or terminated and might reasonably be considered to have failed. Thus, the question we ask is: Why do some SBIR projects fail and others do not?

---

[1] See https://sbir.nih.gov/statistics/award-data. The SBIR program supported by NIH is the second largest SBIR program in the United States, second only to that supported by the Department of Defense.

[2] Following Leyden and Link (2015) and Nightingale (1998), we think of science, the precursor to new technology, as the search for new knowledge; the search is based on observed facts and truths. Science begins with known starting conditions and searches for unknown end results. As defined, science is shrouded in uncertainty because the end results are unknown. We think of new technology as the application of knowledge, learned through science, to some known problem.

While academic studies have been conducted on characteristics of successful NIH-sponsored projects that are commercialized (e.g., Link and Ruhm 2009; Link and Scott 2010; Siegel and Wessner 2012; Gicheva and Link 2016), little is known about those research projects that fail. Identifying covariates with project failure might provide the NIH, as well as other public agencies that competitively fund firms' research, targets to increase the effectiveness of its research awards.

The remainder of this paper is outlined as follows. In "The Small Bussiness Innovation Research Program" Section, we briefly describe the SBIR program and the dataset of NIH-funded SBIR projects that we analyze in this paper. In "Explanations for Project Failure" Section, we discuss alternative explanations for project failure. In "Model of Project Failure" Section, we introduce a probability model of failure along with descriptive statistics on the relevant data we use to test this model. In "Econometric Findings" Section, we present our empirical findings; we compare our findings to related research on project success, keeping in mind that in the literature SBIR project success is measured in terms of the probability of commercialization and only about one-half of those projects that do not fail do in fact commercialize their technology. "Discussion and Concluding Remarks" Section concludes the paper with a discussion of our findings as well as an outline of an agenda for future research.

The Small Business Innovation Research program

The SBIR program is a set-aside program.[3] Agencies are required to set aside a portion of their extramural research budget for small firms (500 or fewer employees). The argument for this focus on small firms was set forth in the Small Business Innovation Development Act of 1982: "small business is the principal source of significant innovations in the Nation" and "small businesses are among the most cost-effective performers of research and development and are particularly capable of developing research and development results into new products."

SBIR-funded projects can be described in terms of three designated phases. Phase I awards are small and are intended to assist firms assess the feasibility of an idea's scientific and commercial potential in response to the funding agency's objectives, and they generally last for six-months.[4] Phase II awards are focused on the initial steps toward commercialization, and they generally last for two years.[5] Further work on the commercialization of the project is to occur during so-called Phase III. To ensure that the developed new technology can move into the marketplace, firms are expected during Phase III to obtain investments from sources other than the SBIR-funding program.

Because the 1982 Act was not permanent, it has been reauthorized over the years along with occasional amendments to modify the structure of the SBIR program. When Congress reauthorized the SBIR program in 2000, it mandated that the National Research Council (NRC), the research arm of the National Academies, conduct an evaluation of the economic benefits associated with the program. In response, the NRC developed and administered in 2005 a

[3] For the legislative background on the SBIR program see Link and Link (2009), Link and Scott (2010, 2013), and Leyden and Link (2015a).
[4] Phase I awards were originally capped at $50,000; the current upper bound is $150,000.
[5] Phase II awards were originally capped at $500,000; the current upper bound is $1 million.

comprehensive survey of completed Phase II projects as part of its evaluation process. The NIH was among the five agencies studied.[6]

Our focus on NIH is motivated by the fact that the net social benefits associated with commercialized products funded by NIH's SBIR program are extraordinarily large, especially in comparison to those SBIR projects funded by other agencies.[7] Thus, identifying policy levers associated with reducing failure among NIH funded projects should have positive net social benefits.

The NRC database arguably represents one of the most complete compilations of information on the innovative behavior of small technology-based U.S. firms. Perhaps more important than that is the fact that it conttains information on the gender ownership of each firm.

Over the period of time on which the survey focused (1992–2001), 2497 Phase II projects were funded through NIH.[8] As shown in Table 1, our final random sample contains 495 projects which represents 29.5% of the sampling population.

Table 1. Sampling information from the population of NIH-funded phase II projects 1992–2001

Population of phase II projects	**2497**
Sampling population	1678
Survey responses	496
Random sample of responses*	495
Final sample of projects	461
Final sample of projects that failed for any reason	99

*The NRC Steering Committee, when structuring the survey, decided to include additional projects in the sampling population. The criterion for these additional projects was that they had to have commercialization revenues in a predetermined amount by 2005 so that they could be characterized, for illustration purposes in the NRC's final report to Congress, as an extremely successful project. Non-randomly selected projects are clearly an important part of the NRC's final report and should not be dismissed, but we deleted the one such project funded by NIH to create a random sample of 495 projects so that we could make generalizations about the NIH SBIR program as a whole

Explanations for project failure

"The concept of project failure is nebulous" (Pinto and Mantel 1990, p 269), and thus the theoretical literature on project failure is both conceptual and limited. Perhaps the most complete review of the so-called failure literature is by Shepherd and Wiklund (2006). They summarize three general explanations for project failure; their arguments are not specific to R&D projects

[6] Eleven agencies currently participate in the SBIR program: Environmental Protection Agency (EPA), National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), and the Departments of Agriculture (USDA), Commerce (DoC), Defense (DoD), Education (ED), Energy (DOE), Health and Human Services (HHS, particularly NIH), Transportation (DoT), and most recently the Department of Homeland Security (DHS). The NRC study focused on the five largest SBIR programs; those at DoD, NIH, DOE, NASA, and NSF.
[7] Allen et al. (2012) develop a model that shows for the benefit-to-cost ratio associated with NIH's program to equal unity, the elasticity of demand for commercialized projects from that program would have to be greater than 50. This implies, for any reasonable value of the elasticity of demand for a new technology, the resulting benefit-to-cost ratio would be extraordinarily large.
[8] Projects funded in 2001 were implicitly given four years to complete the Phase II research and enter into or even complete Phase III. Thus, projects funded in 2001 were ithe last cohort of projects considered by the NRC for the 2005 survey.

or, more to the point, their arguments are not specific to failures of scientific research. Yet, because of a void of more specific literature, Shepherd and Wiklund's (2006) review is not only a reasonable starting point, but also it is one from which we can formulate hypotheses.

First, projects or even businesses fail because of a liability of newness: "The liability of newness [i.e., lack of experience] relates to the actions and learning that the management team and employees must undergo to overcome the major challenges of adaptation to the internal and external environments of new organizations" (Shepherd and Wiklund 2006 p 5).[9] Nixon et al. (2012) embrace this concept as they argue that leadership is critical for project success, and newness can be synonymous with a lack of leadership. Second, projects may fail because of overconfidence in knowledge, which follows from the hubris theory of entrepreneurship as argued by Hayward et al. (2006). With overconfidence comes hubris, and with hubris comes a tendency to deprive the ventures of needed resources and resourcefulness. This lack of resources will then increase the likelihood of failure. Third, projects may fail because of insufficient human capital.[10] This argument or theoretical explanation for failure traces to Becker (1975), although Lazear (2005) has formalized the relationship between human capital and successful entrepreneurial behavior.

Taken as a whole, the above arguments suggest that probability of failure decreases (increases) as the experience base and human capital of either a project manager or firm increases (decreases), other factors remaining constant. In addition to following the so-called literature on project failure, these relationships also follow from the empirical literature related to the success of SBIR projects. The theoretical (e.g., Leyden and Link 2015b) and empirical (e.g., Link and Ruhm 2009; Link and Scott 2010; Siegel and Wessner 2012; Gicheva and Link 2016) literature on SBIR project success, measured in terms of project commercialization, is robust in its findings that human capital is positively related to the probability of project success, and thus one might cautiously infer that it is negatively related to the probability of project failure. We discuss this literature in greater detail below with reference to the independent variables in our econometric model.

Model of project failure

Our model for the probability of project failure can be represented as:

$$P(failure = 1) = \mathrm{P}(\beta'\mathbf{X} + \varepsilon > 0) = \Phi(\beta'\mathbf{X}) \tag{1}$$

where *failure* is a dichotomous variable, **X** is a vector of variables representing the experience base and human capital, the gender of the owner of the firm, and other controls, β is a vector of coefficients to be estimated, ε is an error term capturing all determinants of *failure* not included in **X** and is assumed to be normally distributed with mean 0 and variance 1, and Φ is the standard normal cumulative density function (CDF) such that Eq. (1) will be estimated as a probit model.

---

[9] This argument traces to Stinchcombe (1965).

[10] A recent application of this human capital argument had been offered by Sauser et al. (2009) in terms of the success, or lack thereof, of the Mars Climate Orbiter.

To arrive at our final sample of SBIR projects, we first deleted those Phase II projects that were still ongoing, that is, not discontinued or terminated but have not yet been completed at the time of the NRC survey; 2005. See Table 1. Thus, our sample was reduced from 495 to 461.[11] This reduction in the size of the sample has two pragmatic benefits for this study. One, our final sample of 461 projects consists only of completed projects and failed projects (defined below) thus allowing for a clear dichotomy between failed and not-failed projects; and two, the NRC database includes limited survey information on not-yet-completed projects.

We define a failed project simply as one that had been discontinued or terminated for any reason by the time of the 2005 NRC survey with no sales or additional funding having resulted from the project. It is important to emphasize that the term *failed* is our term; the NRC survey refers to such projects only as being discontinued without sales or additional funding. However, this operational definition of project failure is not at odds with others' definition of project failure (e.g., Pinto and Mantel 1990). As also shown in Table 1, of the 461 completed projects, 362 did not fail but 99 did.

From Eq. (1), we control for the experience base and human capital of the firm through three variables. The experience base of the firm is measured in terms of the number of Phase II awards the firm previously received related to the project/technology supported by the current Phase II award, *simawds*. Available human capital is measured through two variables. The first variable is dichotomous, quantifying if a founder of the firm had a business background, *buss*. The second human capital variable is also dichotomous quantifying if university faculty were involved in the current research project, *univhc*. Also, the size of the Phase II award (logged thousands of $2009), ln(*award*), is held constant as is the ownership gender of the firm, *womanown*. Descriptive statistics on these variables are in Table 2.

Table 2. Descriptive statistics (n = 461)

Variable	Mean	Standard Deviation	Range
failure	0.215	0.411	0/1
simawds	0.983	3.144	0–28
buss	0.388	0.488	0/1
univhc	0.360	0.481	0/1
award	690.28	216.24	17.61–1719.73
womanown	0.148	0.355	0/1

The variable *award* is measured in thousands of $2009

NIH is organized by centers and institutes. To control for differences in the scope of Phase II research, we also control for the funding center or institute. From an institutional perspective, Table 3 reports means for *failure*, by centers and institutes. Other variables held constant, we have no priors about institutional differences in the probability of failure. We therefore estimate model specifications with and without controls for the three most prevalent institutes in our data:

[11] The sample of 495 projects is a random sample of all NIH SBIR awards from 1992 through 2001. The mean SBIR award amount in the sample of 495 projects is $676.82 thousand ($2009). Following Jankowski (1993), award amounts were adjusted to $2009 by the GDP deflator. The mean SBIR amount in the sample of 461 projects is $690.28 thousand ($2009). However, the latter mean is not significantly different than the mean award amount from the random sample of 495 projects (t = 1.34, Pr > |t| = 0.182). Thus, we refer to the sample of 461 projects as a random sample representative of Phase II projects over the relevant time period.

NCI, NHLBI, and NIAID.[12] As an additional sensitivity analysis, we also control for secular trends that may affect the probability of failure via a linear time trend, *year*. Similar to the institute controls, we have no priors as to the effect of the linear time trend.

Table 3. Mean failure rates, by NIH centers and institutes (n = 461)

Institute	**n**	***failure***
NCCIH	2	0.500
NCI	61	0.230
NCRR	24	0.083
NEI	7	0.143
NHLBI	60	0.317
NIA	33	0.273
NIAAA	9	0.111
NIAID	48	0.333
NIAMS	9	0.556
NICHD	31	0.065
NIDA	26	0.077
NIDCD	15	0.267
NIDCR	5	0.800
NIDDK	25	0.200
NIEHS	13	0.154
NIGMS	31	0.129
NIMH	25	0.080
NINDS	34	0.176
NINR	2	0
NLM	1	0
	461	

NCCIH National Center for Complementary and Integrative Health (formally the National Center for Complementary and Alternative Medicine), *NCI* National Cancer Institute, *NCRR* National Center for Research Resources (dissolved in 2011), *NEI* National Eye Institute, *NHLBI* National Heart, Lung, and Blood Institute, *NIA* National Institute on Aging, *NIAAA* National Alcohol Abuse and Alcoholism, *NIAID* National Institute of Allergy and Infectious Diseases, *NIAMS* National Institute of Arthritis and Musculoskeletal and Skin Diseases, *NICHD* Eunice Kennedy Shriver National Institute of Child Health and Human Development, *NIDA* National Institute on Drug Abuse, *NIDCD* National Institute on Deafness and Other Communication Disorders, *NIDCR* National Institute of Dental and Craniofacial Research, *NIDDK* National Institute of Diabetes and Digestive and Kidney Diseases, *NIEHS* National Institute of Environmental Health Sciences, *NIGMS* National Institute of General Medical Sciences, *NIMH* National Institute of Mental Health, *NINDS* National Institute on Neurological Disorders and Stroke, *NINR* National Institute of Nursing Research, *NLM* National Library of Medicine

Based on the general arguments about project failure from "Explanations for Project Failure" Section, we hypothesize that there are both firm-level characteristics and project-level characteristics related to failure. The variables *simawds* and *buss* are characteristics of the firm, and the variable *univhc* is a project characteristic. We hypothesize that both sets of variables will be negatively related to failure. To the extent that the Phase II award amount proxies the

[12] The relatively small sample size of our data relative to the number of centers and institutes represented does not support controlling for every center and institute represented. We explored controlling for additional centers and institutes and grouping centers and institutes in a variety of combinations. We found that our primary results were not sensitive to the specification of the center and institute controls.

complexity of the underlying science and technology development, we hypothesize that the project variable ln(*award*) is positively related to failure.

Our consideration of the gender ownership of the firm, *womanown*, is exploratory motivated by the programmatic emphasis of funding woman-owned firms.[13] Despite the exploratory motivation for including *womanown*, we treat it as endogenous because we find it plausible that *womanown* might be correlated with the unobserved determinants of *failure* for at least two possible reasons.[14] First, the programmatic emphasis on woman-owned firms may result in a difference in the distribution of technical review scores for funded projects from woman-owned firms relative to those of male-owned firms. If technical review scores are correlated with the probability of failure, then the omitted variable for technical review scores is correlated with *womanown* and therefore could bias our estimate of the effect of female ownership. Second, we find it plausible that woman-owned firms might propose to commercialize different types of technologies than male-owned firms, which might have different inherent probabilities of failure. Thus, the omitted variable of technology type might be correlated with *womanown* and therefore could bias our estimate of the effect of female ownership.

To address the potential for *womanown* to be correlated with the unobserved determinants of *failure*, we specify the following descriptive model of *womanown*.

$$\mathrm{P}(womanown = 1) = P(\gamma'\mathbf{Z} + \eta > 0) = \Phi(\gamma'\mathbf{Z}) \qquad (2)$$

where *womanown* is as defined before, **Z** is a vector of control variables, γ is a vector of coefficients to be estimated, and η is an error term capturing all determinants of *womanown* not included in **Z** and is assumed to be normally distributed with mean 0 and variance 1. To allow for a correlation between the unobserved determinants of *failure* and *womanown*, we assume that ε and η are distributed joint normal with correlation ρ; we thus estimate Eqs. (1) and (2) simultaneously as a bivariate probit model.[15] Given the exploratory nature of our interest in *womanown*, we estimate Eq. (2) as a statistical reduced form such that all variables in **X** also appear in **Z**. As shown by Wilde (2000), the bivariate probit model is identified without exclusion restrictions provided the regressor matrix has full rank, as is the case in our model. We specify a different set of institute controls for **Z**; however, to partially proxy for the possibility that woman-owned firms might pursue different technologies than male-owned firms. Thus, **Z** includes controls for NIAAA/NIDA (combined), NIMH, and NICHD.[16] Although it is

[13] The 1992 reauthorization also emphasized minority ownership. Although we have information on minority ownership, the prevalence of minority ownership in our data is too low to allow a rigorous analysis of minority ownership. To assess the sensitivity of our results, we estimated all econometric models including minority ownership as an exogenous determinant of failure and found that it did not qualitatively change our results.

[14] Link and Wright (2015) explored the statistical relationship between project failure and gender of firm ownership using combined SBIR data from DoD, NIH, DOE, NASA, and NSF. Their single-equation analysis did not address the endogenous nature of woman-owned firms. Our analysis not only overcomes that econometric shortcoming, but also because of our focus on NIH-funded projects we are able to hold constant center and institute effects.

[15] We used Stata version 13 for our estimation.

[16] These institute controls were chosen based on our perception that NIAAA, NIDA, NIMH, and NICHD were, relative to the other institutes in our data, more likely to fund "service" technologies (e.g., novel behavioral therapies or educational programs) as opposed to "manufacturing" technologies (i.e., pharmaceutical compounds or medical devices). As this reasoning is admittedly *ad hoc*, we explored other sets of controls for centers and institutes

possible that the differing institutional controls in **X** and **Z** may provide some identifying variation, we do not consider them to be identifying restrictions.

Table 4. Bivariate probit estimates of female ownership (n = 461)

	Model 1	**Model 2**	**Model 3**
ln(*award*)	0.793***	0.742***	0.720***
	(0.233)	(0.250)	(0.243)
	[0.169]	[0.153]	[0.148]
simawds	0.0951***	0.0998***	0.101***
	(0.0293)	(0.0299)	(0.0306)
	[0.0203]	[0.0205]	[0.0208]
buss	−0.237	−0.269*	−0.280*
	(0.161)	(0.158)	(0.160)
	[−0.0494]	[−0.0538]	[−0.0560]
univhc	0.138	0.194	0.177
	(0.154)	(0.155)	(0.156)
	[0.0299]	[0.0407]	[0.0371]
Institute			
NIAAA/NIDA		0.803***	0.844***
		(0.262)	(0.239)
		[0.219]	[0.235]
NIMH		0.189	0.122
		(0.309)	(0.301)
		[0.0397]	[0.0249]
NICHD		0.0795	−0.0144
		(0.316)	(0.333)
		[0.0157]	[−0.00273]
year (1991 set to 0)			0.0136
			(0.0300)
			[0.00278]
Intercept	−6.291***	−6.081***	−6.005***
	(1.525)	(1.641)	(1.594)
ρ	0.950*	0.840*	0.752*

Standard errors in parentheses, marginal effects in square brackets; standard errors on the marginal effect were computed using the delta method. "Marginal effects" for discrete covariates are discrete changes in the predicted probability of the outcome
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Econometric findings

We first consider results from bivariate probit models of the probability of a woman-owned firm receiving an award. The results in Table 4 are stable across model specifications. The coefficients on ln(*award*) and on *simawds* are positive, highly significant, and of similar magnitudes across models. The coefficient on *buss* is consistently negative, but insignificant in model 1 and only marginally significant in models 2 and 3. The coefficient on *univhc* is positive and insignificant in all models. Regarding institutes, only the combination of NIAAA/NIDA is a significant predictor of female ownership. The linear time trend, *year*, is insignificant in model 3 and has no meaningful impact on any coefficient except that on the indictor for NICHD, which

in **Z** following the same approach we used to explore controls in **X**. Our primary results are not sensitive to the specific controls used.

switches from positive and insignificant to negative and insignificant. The estimate of ρ is positive and marginally significant in all models, indicating a positive correlation between the unobserved determinants of *failure*, ε in Eq. (1), and of *womanown*, η in equation.

Table 5. Bivariate probit estimates of failure (n = 461)

	Model 1	**Model 2**	**Model 3**
womanown	−1.266***	−1.114***	−0.960**
	(0.144)	(0.347)	(0.403)
	[−0.267]	[−0.237]	[−0.206]
ln(*award*)	0.188	0.126	0.0958
	(0.168)	(0.194)	(0.191)
	[0.0578]	[0.0375]	[0.0273]
simawds	−0.0552	−0.0900	−0.120
	(0.0635)	(0.0711)	(0.0738)
	[−0.0170]	[−0.0268]	[−0.0341]
buss	−0.267**	−0.236*	−0.144
	(0.127)	(0.131)	(0.141)
	[−0.0812]	[−0.0695]	[−0.0407]
univhc	0.0765	0.0971	0.0766
	(0.124)	(0.128)	(0.133)
	[0.0237]	[0.0292]	[0.0220]
Institute			
NCI		0.0436	0.106
		(0.169)	(0.183)
		[0.0126]	[0.0295]
NHLBI		0.282*	0.384**
		(0.169)	(0.186)
		[0.0875]	[0.116]
NIAID		0.324*	0.320
		(0.189)	(0.200)
		[0.102]	[0.0947]
year (1991 set to 0)			−0.0914***
			(0.0283)
			[−0.0260]
Intercept	−1.601	−1.339	−0.648
	(1.079)	(1.202)	(1.226)

Standard errors in parentheses, marginal effects in square brackets; standard errors on the marginal effect were computed using the delta method. "Marginal effects" for discrete covariates are discrete changes in the predicted probability of the outcome
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5 presents bivariate probit estimates for models of the probability of failure that account for the potential endogeneity of *womanown*. We find that *womanown* is negative and highly significant, with a marginal effect of more than 20% points in all models.[17] The coefficient on ln(*award*), although insignificant in all models, has the expected positive association with the probability of failure once the potential endogeneity of *womanown* is addressed. *simawds* and

[17] See Wright and Link (2015) who also find that woman-owned firms have a lower probability of failure.

buss remain negative, but *simawds* is no longer significant. The variable *buss* is now significant in models 1 and 2, with a marginal effect of approximately 7% points.[18]

Our findings are not inconsistent with the empirical literature related to SBIR project success measured in terms of commercialization; however, the relationship between project failure and commercialization is not perfectly inverse. A project that does not fail might still not be a project that commercializes. Link and Scott (2010) show that among non-discontinued projects, the probability of commercialization is about 50%. Still, a comparison of the literature is important. Conditional on a project not being discontinued or failing, Link and Scott (2010) and Gicheva and Link (2016) find that firms that in the past received SBIR awards related to similar technology as that researched in the current award (i.e., *simawds*) have a greater probability of commercialization. Link and Ruhm (2009) find that when a firm involves a university in the project, the probability of commercialization increases; however, Link and Ruhm did not specifically focus on faculty involvement.[19] Our findings are unique in terms of the relationship between firm with founders with a business background and the probability of failure because others (e.g., Link and Scott 2010) found no relationship between this variable and the probability of commercialization.

Discussion and concluding remarks

The SBIR program is the major source of public funding in the United States for research by small firms on new technologies, and NIH is a major contributor to that funding agenda. Although previous research has explored the determinants of success for NIH SBIR projects that are commercialized (Link and Ruhm 2009; Link and Scott 2010; Siegel and Wessner; Gicheva and Link 2016), we know little about the determinants of project failure. This paper provides important, new evidence on the characteristics of NIH SBIR projects that fail.

We explored the association between female ownership and the probability of failure because the 1992 reauthorization of the SBIR program included a focus on woman-owned firms. Although we had no a priori expectation about the direction of the relationship between female ownership and the probability of failure, we did have concerns that female ownership might be correlated with the unobserved determinants of failure. That is, female ownership may be endogenous. To address this concern, we estimated bivariate probit models that allowed a correlation between the unobserved determinants of failure and of female ownership. We find, after correcting for endogeneity, that female ownership is negatively and highly significantly associated with failure. Because we did not have a theoretically motivated model of female ownership and relied solely on functional form to identify the model, we do not consider these estimates to be causal. Instead, our results suggest that we are missing potentially important determinants of project failure that are correlated with female ownership. We speculate that the most likely omitted variables are the technical review score of an SBIR proposal and the type of technology proposed and investigated (e.g., behavioral interventions versus pharmacological compounds).

---

[18] The marginal effect of *buss* was calculated as the difference in the predicted probability of failure associated with changing buss from 0 to 1, holding all other covariates fixed.

[19] Link (2015) discusses the myriad ways that university resources are used by firms in their SBIR research projects.

Beyond exploring the role of female ownership, we examined other possible determinants of failure as suggested by previous studies (e.g., Pinto and Mantel 1990; Shepherd and Wiklund, 2006). After controlling for endogeneity, only the business background of the founder was significantly related to failure, and that relationship was negative. Another proxy for human capital, the presence of a university partner, was unexpectedly positively associated with failure, but this result was not statistically significant.[20]

Consistent with expectations, we find that larger awards, which we consider a proxy for project complexity, are associated with an increased probability of failure. This finding is not significant. However, larger awards are positively associated with the probability of a woman-owned firm receiving an SBIR award.

Our findings in this paper should be viewed as exploratory and preliminary. First, our data relate to publicly funded small U.S. firms, and thus generalizations beyond that group should be made very cautiously. Second, due to our inability to control for all factors that could possibly be associated with project failure (e.g., technical review scores), our findings are at best suggestive. With these caveats in mind, our analysis does open the door for a yet-to-be systematically studied area of research, one that is clearly important for providing possible guideposts to both public agencies and private firms that fund scientific research.

References

Allen, S. D., Layson, S. K., & Link, A. N. (2012). Public gains from entrepreneurial research: Inferences about the economic value of public support of the small business innovation research program. *Research Evaluation, 21*(2), 105–112.

Becker, G. S. (1975). *Human capital: A theoretical and empirical analysis*. Chicago: University of Chicago Press.

Gicheva, D., & Link, A. N. (2016). On the economic performance of nascent entrepreneurs. *European Economic Review, 86,* 109–117.

Hayter, C. S. (2011). In search of the rational, profit-maximizing actor: Motivations and growth ambitions among academic entrepreneurs. *Journal of Technology Transfer, 36*(3), 340–352.

Hayter, C. S. (2015). Public or private entrepreneurship? Revisiting motivations and definitions of success among academic entrepreneurs. *Journal of Technology Transfer, 40*(6), 1003–1015.

[20] We thank an anonymous reviewer for suggesting that our findings that women-owned firms have a lower probability of project failure may not be independent of the relationship between the funded project and university involvement in the project. To the extent that it is the case that women-owned firms have a greater likelihood of partnering with university faculty who indend to create a spin-off venture, then the negative relationship between *womanown* and *failure* may not be correctly specified in our model, although the data needed for a more complete specification are not available. See Hayter (2011, 2015) for insight about university spin-offs. Future research in this area might explore this issue.

Hayward, M., Shepherd, D. A., & Griffin, D. (2006). A hubris theory of entrepreneurship. *Management Science, 52*(2), 160–172.

Jankowski, J. E. (1993). Do we need a price index for industrial R&D? *Research Policy, 22*(3), 195–205.

Lazear, E. P. (2005). Entrepreneurship. *Journal of Labor Economics, 23*(4), 649–680.

Leyden, D. P., & Link, A. N. (2015a). *Public sector entrepreneurship: U.S. technology and innovation policy*. New York: Oxford University Press.

Leyden, D. P., & Link, A. N. (2015b). Toward a theory of the entrepreneurial process. *Small Business Economics, 4*(3), 475–484.

Link, A. N. (2015). Capturing knowledge: Private gains and public gains from university research partnerships. *Foundations and Trends in Entrepreneurship, 11*(3), 139–206.

Link, A. N., & Link, J. R. (2009). *Government as entrepreneur*. New York: Oxford University Press.

Link, A. N., & Ruhm, C. J. (2009). Bringing science to market: Commercializing from NIH SBIR awards. *Economics of Innovation and New Technology, 18*(4), 381–402.

Link, A. N., & Scott, J. T. (2010). Government as entrepreneur: Evaluating the commercialization success of SBIR projects. *Research Policy, 39*(5), 589–601.

Link, A. N., & Scott, J. T. (2013). *Bending the arc of innovation: Public support of R&D in small, entrepreneurial firms*. New York: Palgrave-Macmillan.

Link, A. N., & Wright, M. (2015). On the failure of R&D Projects. *IEEE Transactions on Engineering Management, 62*(4), 442–448.

Nightingale, P. (1998). A cognitive model of innovation. *Research Policy, 27*(7), 689–709.

Nixon, P., Harrington, M., & Parker, D. (2012). Leadership performance is significant to project success or failure: A critical analysis. *International Journal of Productivity and Performance Management, 61*(2), 204–216.

Pinto, J. K., & Mantel, S. J., Jr. (1990). The causes of project failure. *IEEE Transactions on Engineering Management, 37*(4), 269–276.

Sauser, B. J., Reilly, R. R., & Shenhar, A. J. (2009). Why projects fail? How contingency theory can provide new insights—a comparative analysis of NASA's mars climate orbiter loss. *International Journal of Project Management, 27,* 665–679.

Shepherd, D. A., & Wiklund, J. (2006). Successes and failures at research on business failure and learning from It. *Foundations and Trends in Entrepreneurship, 2*(1), 1–35.

Siegel, D. S., & Wessner, C. W. (2012). Universities and the success of entrepreneurial ventures: Evidence from the small business innovation research program. *Journal of Technology Transfer, 37*(4), 404–415.

Stinchcombe, A. L. (1965). Social structure and organizations. In J. G. March (Ed.), *Handbook of organizations* (pp. 142–193). Chicago: Rand McNally and Company.

Wilde, J. (2000). Identification of multiple equation probit models with endogenous dummy regressors. *Economics Letters, 69*(3), 309–312.